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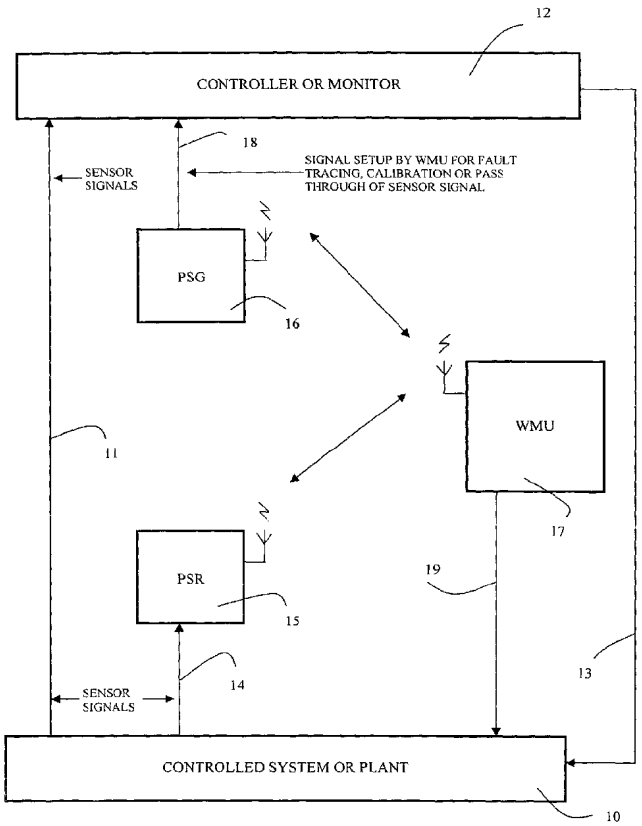
(54) Title: WIRELESS OPERATED SIGNAL TESTER



(57) Abstract: The present invention provides a method, a system and devices for wireless signal testing when conducting maintenance operations on controllers and alarm and monitor systems (12) controlling a process (10) such as processing industry installations, marine ship motors, offshore installations etc., and other forms of feedback control systems of any kind. A programmable wireless signal reader (15) transmit sensor signals to a programmable wireless signal generator (17) where the transmission and the ouputing of the output sensor signals (18, 19) is supervised and the signal form is defined in a wireless main controlling unit (17).

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SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

Wireless Operated Signal Tester

Field of the Invention

The present invention relates to a method and a system for fault tracing, signal logging, signal generation, signal calibration and/or other diagnostic purposes etc. of sensor signals used in electronic control systems and/or alarm and/or monitor systems that control and regulate a process as processing plants, motors such as marine ship motors and similar devices and/or general feedback control systems of any kind, and especially for a method and system comprising a programmable wireless signal reader that reads sensor signals and transmit said sensor signals wirelessly, a programmable wireless signal generator that receives said wirelessly transmitted sensor signals and that generates outgoing signals associated with said received wirelessly transmitted sensor signals, and a wireless main controlling unit governing said transmission and setup of said wirelessly transmitted sensor signals.

Background of the Invention

Modern control system theory is applicable to a vast majority of engineering problems. The term system comprises everything from man made apparatus to many biological phenomena found in nature. Modern control system theory is therefore a major tool both for engineering tasks and scientific exploration.

In engineering tasks, the basic principal is to provide a controller feeding control signals to the controlled system or plant and to supervise the live or dynamic characteristics of the controlled system or plant over time by monitoring certain parameters and their characteristics in the controlled system or plant.

Based on the monitored parameters, the controller decides action to be taken if there is a deviation from an expected behaviour of the system or plant. These actions can simply be to sound an alarm or to calculate new values for the control signals feed to the

system or plant to correct the unwanted deviation. Feedback systems can be closed loops, semi closed loops or open loops as known to a person skilled in the art.

A necessary feature of control systems is the observability and controllability of the parameters used to control the controlled system or plant. This is mandatory to obtain a working system that provide stability and safety in operation, that is able to avoid damage on the controlled system, to lower the maintenance needs of the controlled system etc.

The maintenance, calibration and verification of sensors generating signals related to the controlled system, maintenance and control of regulating means for the controlled system, maintenance and control of signal paths etc. in the control system is therefore of the outmost importance in controlled systems or plants. It is also mandatory by regulation that some types of controlled systems like marine ship motors, offshore installations, onshore processing plants, certain alarm and monitoring systems for instance in hospitals etc. have a regular verification of sensors, verification of signal paths, a control of calibration etc. to maintain certificates necessary for continued legal operation and use of such equipment or installations.

Although the observability and controllability of the signals in a controlled system is provided, since it is a functioning controlled system, the above mentioned maintenance and similar tasks can be difficult because observability of parameters by a maintenance engineer for example can be obstructed by the layout of the controlled system, the size of the controlled system, the physical distance between components and the controller, the placement of sensors inside a controlled system etc. The signal paths themselves can also be difficult to reach because they can be hidden behind physical obstacles in the controlled system. Even in situations where the maintenance engineer has full observability of parameters, the controllability may be harmed since the maintenance engineer may infringe signals during maintenance work and thereby he may harm the observability of the signals as seen by the controller, and the controller can no longer control the controlled system or plant.

Situations where it is required to identify and change a malfunctioning component, the problem is always first to be able to identify the malfunctioning component. In a controlled system, and especially in feed back systems, this task of locating malfunctioning components can be extremely difficult. Observing a signal may in it self disturb the controlled system. When a malfunctioning signal is identified it is still very difficult to isolate the fault to either a sensor generating the signal, the cable carrying the signal from the sensor to the controller unit or that the fault is present in the controller unit itself. One of the most difficult situations occurs when the fault has an intermittent characteristic where the fault is present a moment, then disappear and then randomly reappear.

The prior art provides some solutions to the problems and difficult situations described above. However, a maintenance operation in prior art may include many types of instruments and especially a need to provide new signal cables in a test setup to help the maintenance engineer to be able to identify and solve the task at hand. In huge installations of controlled or monitored systems this is a severe shortcoming. Another well known problem is that attachment of instrument probes to signal cables may harm or infringe the signal in such a way that the observability and controllability of the controlled system is lost, and thereby it is impossible to identify the problem. This is a severe shortcoming in huge or small installations of controlled and/or monitored systems.

Summary of the Invention

The objective of the present invention is to provide a solution to the problems and shortcomings in the prior art described above, by providing a method, a system and devices for radio and/or optical based wireless signal transmission between devices according to the present disclosure, the amended claims and accompanying drawings.

In an example of embodiment of the present invention, a system comprising a programmable wireless signal reader, a programmable wireless signal generator and a

wireless main controlling unit replaces or duplicates existing signal cables/paths in a controlled and/or monitored system or plant.

In another example of embodiment of the present invention, a wireless main controller unit provides means to read a wireless transmitted signal from a sensor, means to store information about the signal such as magnitude of a signal amplitude, signal frequency, shape of signal, patterns of signals, analog or digital signal, voltage level, current level and/or other user defined parameters about the signal.

In another example of embodiment of the present invention, a wireless main controller unit provides means to analyse wireless transmitted signals according to pre-recorded criteria for signal quality, for example an alarm threshold, thereby providing means to identify malfunctioning signals or abnormal situations in the controlled system and thereby transmit alarms and/or instructions to other units of a system.

In another example of embodiment of the present invention, a wireless main controller provides means to correct or compensate a faulty signal in a controlled or monitored system by first reading at least one wireless transmitted signal from a sensor, provides means to perform an analysis of the signal to identify a deviation from a pre-recorded expected signal or simply just means to retransmit the signal to another wireless signal reader or generator according to the present invention, thereby providing an emulation of a physical signal cable with a corrected signal if necessary or just as a copy of the signal first read by the signal reader.

In another example of embodiment of the present invention, a programmable wireless reader comprises means for reading digital or analog signals from sensors, means for converting the analog sensor signals to a digital format and means for wireless transmitting the digital formatted signals. In another embodiment, the programmable wireless reader comprises means for characterising physical aspects of signals such as frequency of the signals, bias levels etc. In another embodiment of the present invention, the programmable wireless reader provides addressing means that identifies

said programmable wireless signal reader as one of two end points of a wireless communication channel.

In another example of embodiment of the present invention, a programmable wireless signal generator provides means for receiving a wireless transmitted sensor signal comprising digital information about the sensor signal, means for generating a replica of the original sensor signal based on the received wireless sensor signal. In another embodiment of the present invention, the programmable wireless generator provides means for receiving and storing information about at least one received wireless sensor signal comprising: magnitude of signal amplitude, signal frequency, shape of signal, patterns of signals, analog or digital signal, voltage level, current level and/or other user defined parameters about the signal. In yet another embodiment of the present invention, the programmable wireless signal generator comprises means for receiving an address identifying said programmable wireless signal generator as one of two end points of a wireless communication channel.

Figure 1 illustrates an example of embodiment of a system according to the present invention;

Figure 2 is a schematic illustration of an example of a wireless main controlling unit according to the present invention;

Figure 3a illustrates a principal layout of a programmable signal reader and a programmable signal generator according to an example of embodiment of the present invention;

Figure 3b illustrates a principal layout of a programmable signal generator with analog output according to an example of embodiment of the present invention;

Figure 3c illustrates a principal layout of a programmable signal reader with analog input according to an example of embodiment of the present invention;

Figure 3d illustrates a principal layout of a programmable signal generator with digital output according to an example of embodiment of the present invention;

Figure 3e illustrates a principal layout of a programmable signal reader with digital input according to an example of embodiment of the present invention;

Figure 3f illustrates a principal layout of a programmable signal reader with a digital interface to a CAN bus according to an example of embodiment of the present invention;

Disclosure of the Invention

Figure 1 illustrates the principal components and use of a system according to an example of embodiment of the present invention. A controlled system or plant 10, like a motor or process industry etc., has sensor output signals 11 feed to a controller or monitor 12 where they are processed to generate a controller signal 13 to the controlled system or plant 10, as known to a person skilled in the art. In addition there is attached a programmable signal reader 15 to sensor signals 14. The programmable signal reader 15 transmits the sensor signals 14 directly to the programmable signal generator 16. The wireless main controller unit 17 governs the communication setup and are supervising the communication channels in addition to initialising the devices 15 and 16 at start-up. In an example of embodiment of the present invention, the wireless communication standard is according to the Bluetooth radio standard. Unlike many other wireless standards, the Bluetooth wireless standard specification includes both link layer and application layer definitions for product developers, which supports data, voice, and content-centric applications. Radios that comply with the Bluetooth wireless specification operate in the unlicensed, 2.4 GHz radio spectrum ensuring communication compatibility worldwide. These radios use a spread spectrum, frequency hopping full-duplex signal at up to 1600 hops/sec. The signal hops among 79 frequencies at 1 MHz intervals to give a high degree of interference immunity. Up to seven simultaneous connections can be established and maintained.

In another example of embodiment of the present invention, the wireless communication is established by optical means like the IrDA standard. In yet another embodiment of the present invention, the wireless communication is established by specially developed radio transceivers with a licensed frequency to establish long-range radio communication between the devices according to the present invention.

Independent of the actual wireless communication used in the examples of embodiments of the present invention, the devices need to follow a predefined protocol to achieve the object of the invention. With reference to figure 1, the operator of the system must instruct the programmable wireless signal reader 15 about which programmable wireless signal generator 16 the device 15 should communicate with. The selection and setup is done via the wireless main controlling unit 17. In this example of embodiment, two Bluetooth connections are used for communication between the wireless main controller unit 17 and the devices 15 and 16 respectively. The five remaining simultaneous Bluetooth connections are used to communicate signals between the device 15 and 16. That is, the programmable wireless reader 15 can simultaneously read five sensor outputs 14 and send them to the programmable wireless signal generator 16. The setup of the devices 15 and 16 from the device 17 also includes a definition of the signal standards used in the sensor signals 14 from the controlled system or plant 10. These signal standard definitions comprises parameters for magnitude of signal amplitude, signal frequency, shape of signal, patterns of signals, analog or digital signal, voltage level, current level and/or other user defined parameters about the signals that has to be regenerated in the device 16 which feeds these regenerated signals as the sensor signals 18 to the controller and/or monitor 12. That is, the wireless main controlling unit 17 sends these schemes to the devices 15 and 16 respectively at the start-up of the session.

Some or all of the sensor signals 14 read by the programmable wireless signal reader 15 communicated to the device 16 can also at the same time be communicated to the wireless main controlling unit 17 which provides means for fault tracing, signal logging, signal analysis, comparing of signal levels with predefined alarm levels, signal calibration and/or for diagnostic purposes etc. as known to a person skilled in the art.

The example in figure 1 has one Bluetooth connection between the programmable wireless reader 15 and the wireless main controlling unit 17. The sensor signals 14 will according to this example of the present invention be multiplexed onto this single communication channel. That is, the channel is dived into packages as known to a person skilled in the art, where the device 15 can communicate a plurality of data and parameters to the device 17.

In another example of embodiment of the present invention, the above-described multiplexing scheme is also used on a connection for data transmission between the devices 15 and 16 to provide a plurality of sensor signals between the devices 15 and 16.

With reference to figure 1, the control signals 13 and 19 are feed back to the controlled system or plant 10 where means arranged in the controlled system or plant acts on the controlled system or plant to achieve the intended control and/or regulation of the controlled system or plant 10. The control signal 19 originates from the controlling unit 17, and in the example it is a replacement of a signal originating from the controller and/or monitor 12. In the example depicted in figure 1 the connection is done directly between the controlling unit 17 and the controlled system or plant 10. In another example of embodiment of the present invention this connection can be achieved by a wireless connection where a programmable wireless reader 15 is attached to the controlling unit 17, and where a programmable wireless generator 16 is attached to the receiving means in the controlled system or plant 10. The same scheme for providing a wireless connection for the signals 13 can be arranged by connecting a device 15 to the controller or monitor 12. A plurality of signals can be arranged in this manner.

Figure 2 illustrates the functional blocks of a wireless main controlling unit according to the present invention. A keyboard 30 and a display 31 provides examples of necessary means for communicating setup parameters etc., as in the examples described above, to a microcontroller 32 running an embedded program that can achieve the necessary tasks according to the invention, by providing setup parameters etc., as in the examples

described above, via the wireless communication port 32 to other devices according to the invention, and by providing communication means to a general interface section 34.

Figure 3a to figure 3f illustrates different arrangements of a programmable wireless signal reader and a programmable signal generator according to the present invention.

Figure 3a illustrates the necessary components in these devices. A microcontroller with an embedded program communicate signals in an I/O section to and from a radio transceiver or optical link in according to a scheme defined by wireless communication between the device and the wireless main controlling unit according to the invention, as described in examples above.

Figure 3b illustrates an example of embodiment of a programmable wireless signal generator where the I/O section comprises a Digital to Analog Converter (DAC) that provides analog signals as defined by the scheme transmitted from the controlling unit to the attached controlled system or plant. The DAC settings, as known to a person skilled in the art, are provided by the scheme.

Figure 3c illustrates an example of embodiment of a programmable wireless signal reader according to the invention that comprises an Analog to Digital Converter (ADC) in the I/O section. The device according to this example can read analog signals, convert the signals to digital form and transmit the data through the wireless channel. The ADC settings, as known to a person skilled in the art, are provided by the scheme transmitted from the controlling unit.

Figure 3d illustrates an example of embodiment of a programmable wireless signal generator where the I/O section comprises a programmable frequency output generator as known to a person skilled in the art. The embedded program in the microcontroller controls the settings of the parameters for the frequency generator selected by the scheme transmitted from the controlling unit.

Figure 3e illustrates an example of embodiment of a programmable wireless signal reader where the I/O section comprises a programmable frequency input level decoding circuitry as known to a person skilled in the art. The embedded program in the microcontroller controls the settings of the parameters for the frequency input level decoder selected by the scheme transmitted from the controlling unit.

Figure 3f is an example of embodiment of a programmable wireless signal reader where the I/O section comprises a CAN buss interface. In this manner, the programmable wireless signal reader can transmit signals from a standard bus definition used in the car industry.

In another example of embodiment of a system according to the present invention, there is attached to a programmable wireless reader or generator 15, 16, a video camera, preferably of the "web" camera type, that by remote control via an embedded program in the microcontroller in the programmable wireless reader or generator 15, 16, can be controlled from the wireless main controlling unit 17. The pictures from the web camera can be transmitted on the wireless channel between the controlling unit 17 and the device 15, 16 and be displayed on the display 31 in the controlling unit 17. In this manner the operator is able to visually survey the situation at one or more places that requires special attention. An example is to visually observe if a control signal from the controller or monitor 10 actually activates a valve for example in an arrangement in the controlled system or plant 10.

In another embodiment of the above described example, there is attached a temperature scanner device to a programmable wireless reader or generator 15, 16. An embedded program in the microcontroller 32 can via a step motor arrangement attached to the temperature scanner device be able to direct the temperature scanner via wireless communication to a desired spot. The web camera helps the operator to identify such spots for temperature scanning. The data from the temperature scanning can be displayed on the display 31 in the controlling unit 17 by transfer of the temperature data over the communication channel.

In yet another example of an embodiment of a system according to the present invention, the interface section 34 in the controlling unit 17 comprises means for communicating with a mobile telephone. In this manner the operator can operate and control the wireless main controlling unit 17 remotely.

In another example of embodiment, the mobile phone connection as described above, transfers data from the system according to the present invention to a remote site for diagnostic purposes. An example is onboard a ship or an offshore installation where a maintenance operator needs to consult experts onshore to be able to solve the maintenance problem at hand.

Claims:

1. Method for wireless fault tracing, signal logging, signal generation, signal calibration and/or other diagnostic purposes etc. of at least one sensor signal (14) in electronic control systems and/or alarm and/or monitor systems (12) that control and/or regulate a process (10) as processing plants, motors such as marine ship motors and similar devices and/or general feedback control systems of any kind, comprising the steps of:

   providing at least one wireless communication channel transmitting said at least one sensor signal (14) between at least one sensor in communication with said process (10) and said electronic control system and/or alarm and/or monitor (12) system controlling said process (10);

   listening to said wireless communication channel for identifying a state or a plurality of states of said at least one sensor signal (14) transmitted in said communication channel; and

   providing means to analyse said state or plurality of states of said at least one sensor signal (14).

2. Method according to claim 1, further comprising the step of:

   providing means to generate at least one sensor signal (18, 19) in communication with said electronic control system and/or alarm and/or monitor system (12) or said process (10) on basis of said state or plurality of states of said at least one sensor signal (14).

3. System for wireless fault tracing, signal logging, signal generation, signal calibration and/or other diagnostic purposes etc. of at least one sensor signal (14) in electronic control systems and/or alarm and/or monitor systems (12) that control and/or regulate a process (10) as processing plants, motors such as

marine ship motors and similar devices and/or general feedback control systems of any kind, comprising:

a programmable wireless signal reader (15) arranged to read at least one analog and/or digital sensor signal (14) from sensors in communication with said process and transmitting said sensor signal in a wireless communication channel in a predefined format;

a programmable wireless signal generator (16) arranged to generate at least one output sensor signal (18, 19) in communication with said electronic control systems and/or alarm and/or monitor system (12) or said process (10) on basis of received information in a predefined format in a wireless communication channel;

a programmable wireless main controlling unit (17) arranged to receive and transmit communications in said communication channels with predefined formats enabling a user via a user interface in said unit to instruct at least one said programmable wireless signal reader (15) to transmit at least one sensor signal (14), and to instruct at least one programmable wireless signal generator (16) to generate at least one said output sensor signal (18) according to a scheme comprising a state or a plurality of states of a sensor signal (14) communicated from said programmable wireless signal reader (15).

4. System according to claim 3, further comprising:

an arrangement to receive said scheme for generating said sensor signal (18,19) in said programmable wireless signal generator (16) from said wireless main controlling unit (17) over a wireless communication channel, thereby enabling a user via said wireless main controlling unit (17) to define an output signal state or a plurality of signal states of said output sensor signal (18,19).

5. Device (15) for reading at least one analog or digital sensor signal (14) from a sensor in communication with a process (10) as processing plants, motors such as marine ship motors and similar devices and/or general feedback control systems of any kind, comprising:

an input section arranged to read said at least one analog or digital sensor signal (14), where said input section is in communication with a microcontroller comprising an embedded program instructing said microcontroller to transmit a state or a plurality of states of said at least one analog or digital sensor signal (14) via a wireless transmission section.

6. Device (15) according to claim 5 wherein said input section comprises one or more digital input registers, one or more analog to digital converters (ADC), one or more frequency detection circuits, pulse width modulation detection circuits, signal level detection circuitry and other forms of input signal decoding circuitry.

7. Device (15) according to claim 5, wherein said wireless transmission section comprises radio transmission circuitry according to the Bluetooth standard.

8. Device according to claim 5, wherein said wireless transmission section comprises optical transmission circuitry according to the IrDA standard.

9. Device (16) for generating at least one analog or digital output sensor signal (18, 19) in communication with an electronic control systems and/or alarm and/or monitor system (12) or a process (10), comprising:

an output section arranged to generate said at least one analog or digital output sensor signal (18, 19) according to a scheme comprising a state or a plurality of states of a sensor signal (14), where said scheme is executed by an embedded program in a microcontroller in communication with said output section.

10. Device (16) according to claim 9, comprising a wireless communication section wherein said scheme is transmitted to said generating device (16) from a wireless main controlling unit (17), where a user via a keyboard (30) and a display (31) attached to said wireless main controlling unit (17) can provide said scheme, thereby enabling said user to define any state or a plurality of states of said output sensor signals (18, 19) generated in said generating device (16).

11. Device (16) according to claim 9, wherein said output section comprises one or more digital output registers, one or more digital to analog converters (DAC), one or more frequency generating circuits, pulse width modulation generating circuits, signal level enabling circuitry and other forms of encoding signal output circuitry.

12. Device (16) according to claim 10, wherein said wireless transmission section comprises radio transmission circuitry according to the Bluetooth standard.

13. Device (16) according to claim 10, wherein said wireless transmission section comprises optical transmission circuitry according to the IrDA standard.

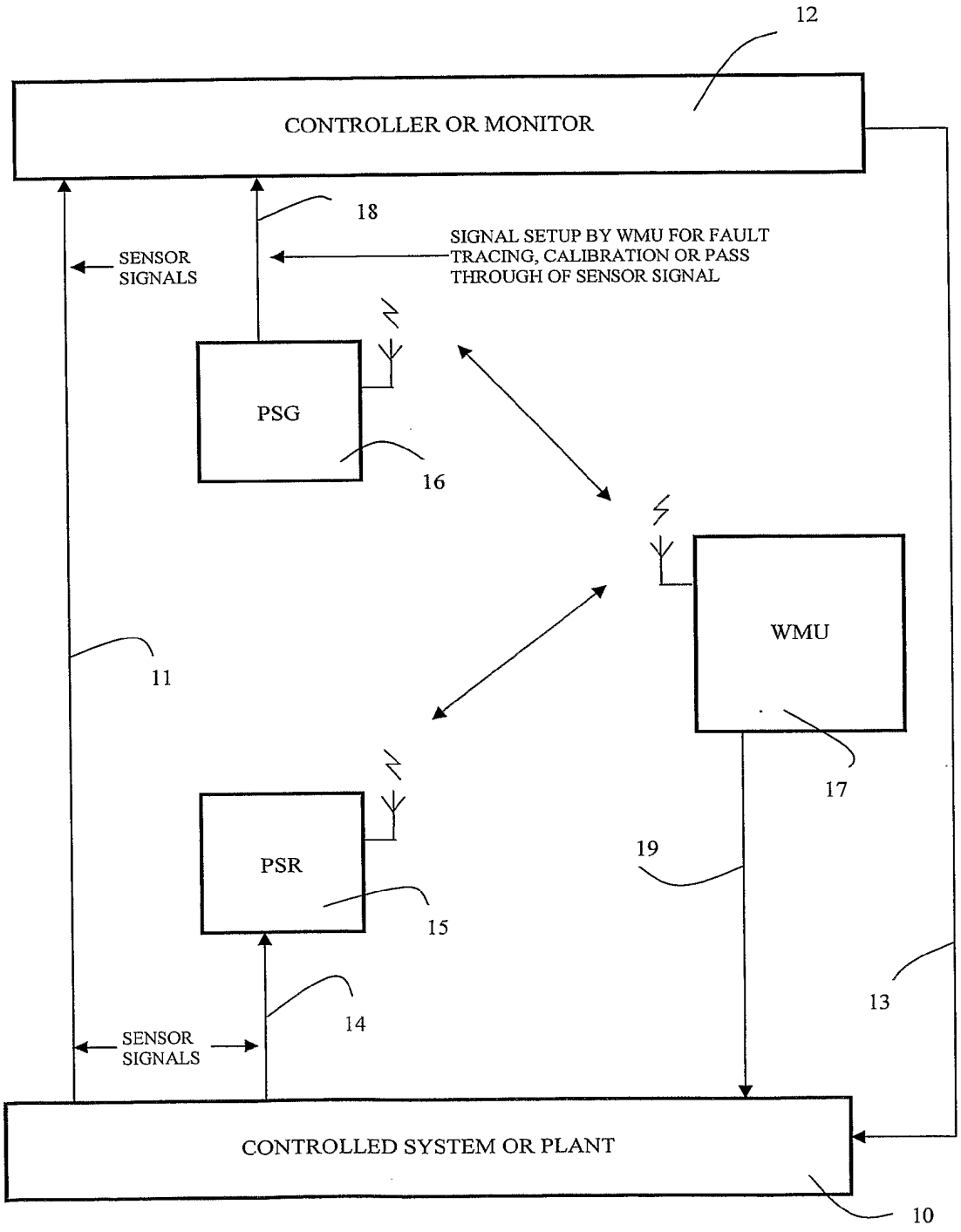

12
CONTROLLER OR MONITOR
18
SIGNAL SETUP BY WMU FOR FAULT TRACING, CALIBRATION OR PASS THROUGH OF SENSOR SIGNAL
SENSOR SIGNALS
PSG
16
WMU
11
17
PSR
19
15
13
14
SENSOR SIGNALS
CONTROLLED SYSTEM OR PLANT
10

Figure 1

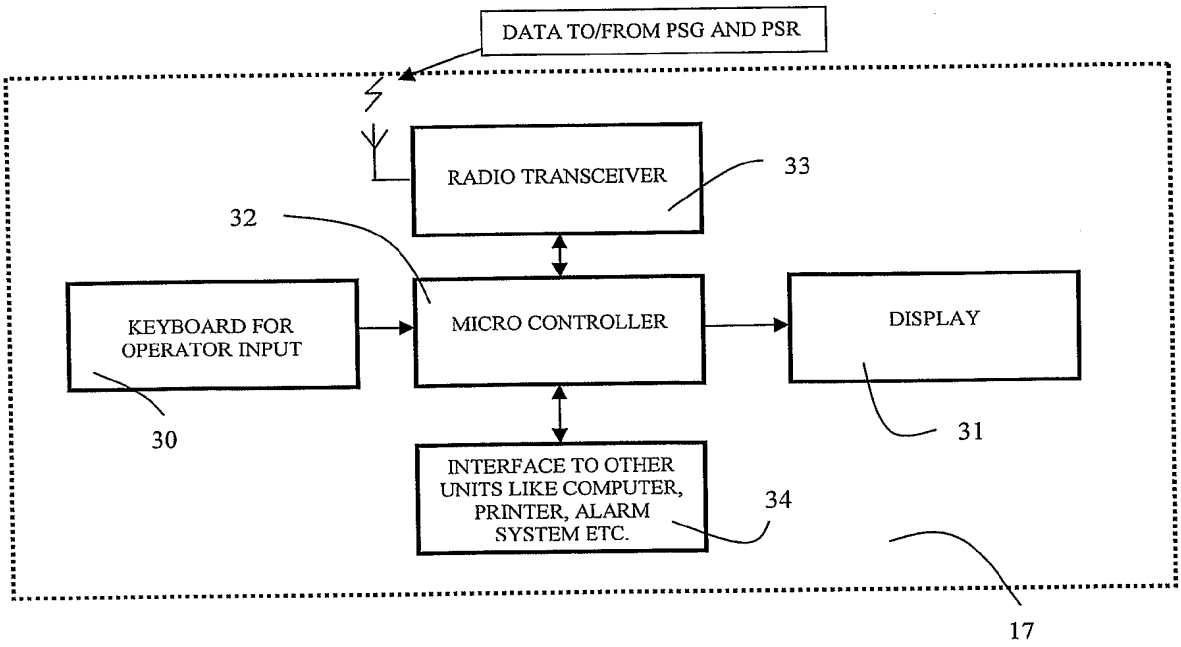

DATA TO/FROM PSG AND PSR
RADIO TRANSCEIVER
33
32
KEYBOARD FOR OPERATOR INPUT
MICRO CONTROLLER
DISPLAY
30
31
INTERFACE TO OTHER UNITS LIKE COMPUTER, PRINTER, ALARM SYSTEM ETC.
34
17

Figure 2

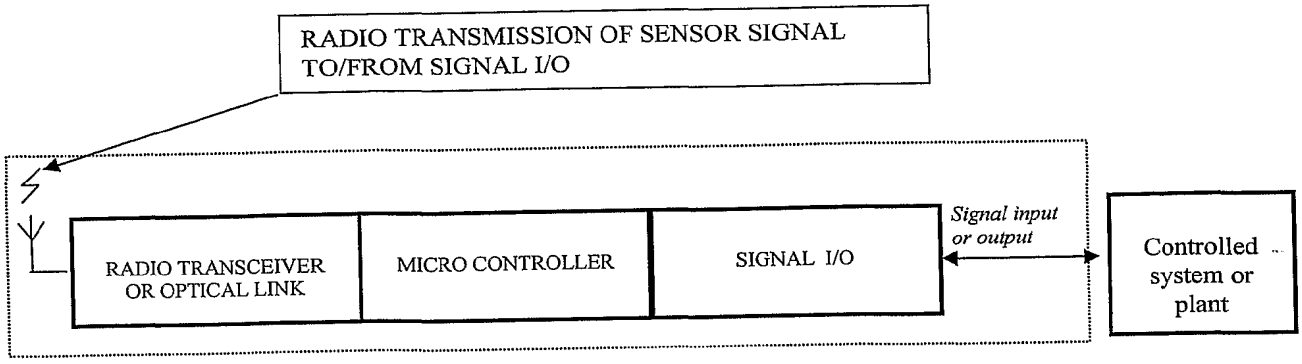
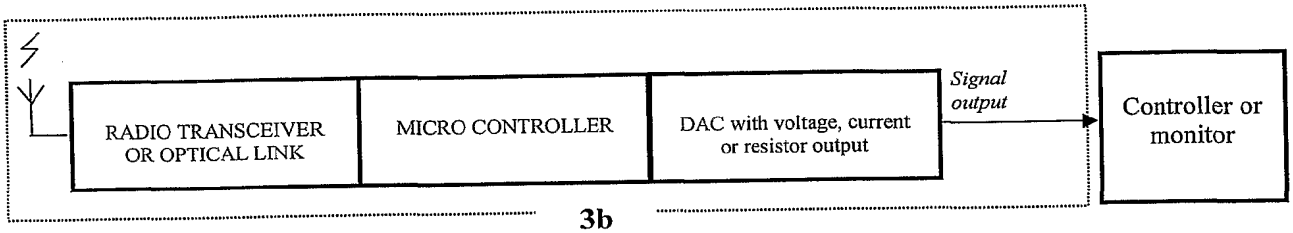


Figure 3a



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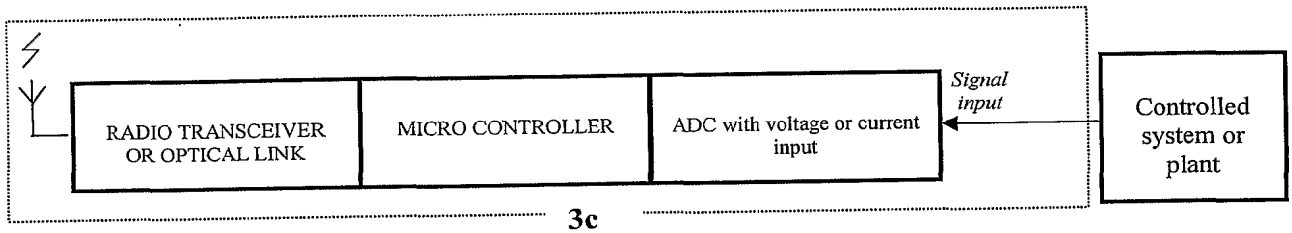
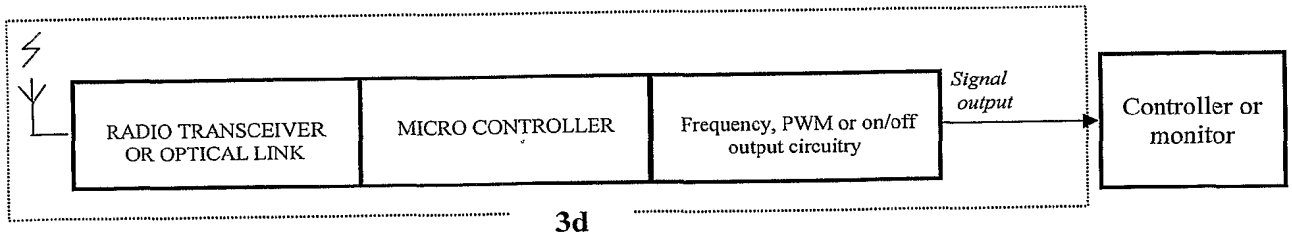
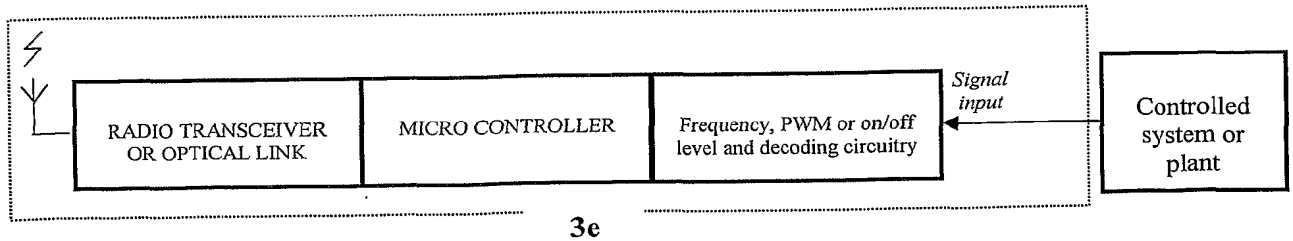


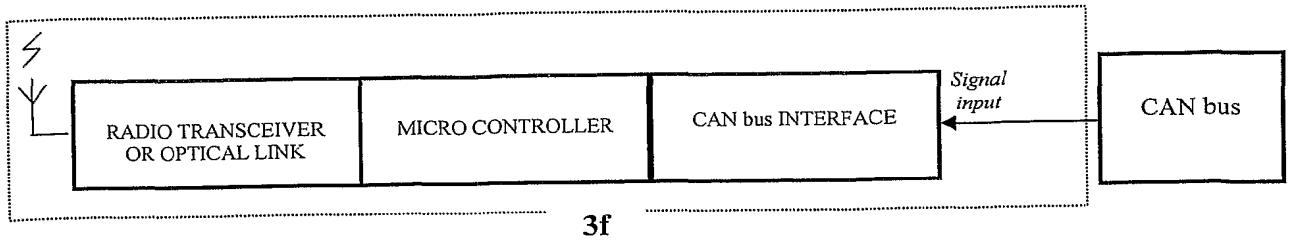
3c



3d



3e



3f

INTERNATIONAL SEARCH REPORT

International application No.
PCT/NO 03/00139

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: G05B 23/02, G06F 11/00, H04B 10/08
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: G05B, H04B, H04L, G06F, G08B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-INTERNAL, IEEE XPLORE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	EP 0472169 A2 (KABUSHIKI KAISHA TOSHIBA), 26 February 1992 (26.02.92), column 6, line 7 - line 48; column 7, line 21 - line 34; column 10, line 39 - line 51, abstract --	1-13
Y	WO 9845779 A1 (CSI TECHNOLOGY, INC.), 15 October 1998 (15.10.98), page 3, line 1 - line 15; page 4, line 1 - line 10; page 6, line 1 - line 19, claim 1, abstract --	1-13
P,A	US 2002169514 A1 (EVREN ERYUREK ET AL), 14 November 2002 (14.11.02), see the whole document --	1-13

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
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